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**INTERGRADATION AMONG RING-NECKED SNAKES
FROM SOUTHERN NEW JERSEY
AND THE DEL-MAR-VA PENINSULA**

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Lack of adequate material has long been the cause of confusion concerning the status of the ring-necked snakes inhabiting southern New Jersey, the Del-Mar-Va Peninsula, and adjacent portions of the, Atlantic Coastal Plain. Some specimens from the region have been identified with *Diadophis punctatus punctatus* (Linné) whereas others have been recorded in the literature as *Diadophis punctatus edwardsii* (Merrem) , depending upon which of these two subspecies the snakes in question most closely resembled. Thus Blanchard, in his posthumous monograph of the genus (1942), reported the northern, or upland, *edwardsii* from as far south as Berlin, Maryland, and the normally southern *punctatus* from as far north as Matawan, New Jersey. If, prior to the time of his death (in 1937) , he had seen as many specimens as there are available now, it would have been obvious to him that, in many parts of the area, individuals that could be identified as *edwardsii* live side by side with snakes indistinguishable from *punctatus* plus many specimens that combine the characters of the two. It is now possible to demonstrate that, as a whole, the ring-necked snakes occurring throughout most of the Del-Mar-Va Peninsula and southern New Jersey constitute an intergrading population between the two forms.

The dearth of specimens that has existed until recent years is reflected in the literature. None of the early writers who published papers on the general area (Davis, Fowler, Stone, Street, etc.) gave any definite records for the two regions. Conant and Bailey (1936, p. 5) and Trapido (1937, p. 14) were the first to report *edwardsii* and *punctatus*, respectively,

from southern New Jersey; McCauley (1941, p. 55) was the first to record ring-necks from the Del-Mar-Va Peninsula. The last-named author listed several localities and gave evidence to prove that intergradation takes place in the eastern shore counties of Maryland. The only other specific references are in Blanchard (*loc. cit.*), Conant (1945), and McCauley (1945).

It is now possible to assemble 74 specimens of *Diadophis* from southern New Jersey and the Del-Mar-Va Peninsula, plus an additional 89 specimens from the immediately contiguous areas. For the loan of many of these snakes and for other assistance I am indebted to the following: Dr. Doris M. Cochran, of the United States National Museum (USNM), Mrs. Helen T. Gaige, formerly of the University of Michigan Museum of Zoology (UMMZ), M. Graham Netting, of the Carnegie Museum (CM), Charles M. Bogert, of the American Museum of Natural History (AMNH), Arthur Loveridge, of the Museum of Comparative Zoology, Dr. E. R. Dunn, of the Academy of Natural Sciences of Philadelphia, (ANSP), Dr. A. H. Wright and Miss Kay Kapp, of Cornell University (CU), and Miss Beatrice Winsor, of the Newark Museum (NM). Robert Teeters, of the Junior Zoological Society of Philadelphia (JZSP), deserves special mention for doing most of the scale counting and for helping in other ways. Dr. Howard K. Gloyd, of the Chicago Academy of Sciences (CA), has carefully checked the manuscript and rendered valuable advice. To Mark Robinson, of Springfield, Pa., Asa Pittman, of Upton, N. J., Nigel O'Connor Wolff, of Rutledge, Pa., the late George Ladd, of Vineland, N. J., William H. Caulwell, of Lakewood, N. J., John Werler, of Staten Island, N. Y., and Carl F. Kauffeld, of the Staten Island Zoo, should go much of the credit for securing many of these snakes in the field.

MATERIAL

Specimens seen, with attendant data, are listed below. The series from the Pocono Mountains was studied to ascertain the amount of variation evident in a more or less typical near-by population of *edwardsii*; the series from southeastern Virginia was examined for information on variability in a reasonably typical near-by population of *punctatus*.

POCONO MOUNTAINS (Northeastern Pennsylvania)-28 specimens.

Monroe County: Henryville (CM 22440-3, 22447); Near Devil's Hole (CM 22444).

Pike County: 10 miles south of Porter's Lake (CM 23230-51).

NORTHERN NEW JERSEY 25 specimens.

Hunterdon County: 5 miles south of Frenchtown (ZSP* 453-5); Kingwood (ZSP 645-7) .

Mercer County: 3 miles west of Princeton (ZSP 3583).

Morris County: (ANSP 3447); Lake Hopatcong (AMNH 58078).

Somerset County: Bernardsville (NM 244.1); Somerville (AMNH 43938); Watchung (AMNH 7736, 14156-8); Watchung Mountains (AMNH 57837),.

Sussex County: Mashipacong Lake (ANSP 16180).

Union County: Berkeley Heights (AMNH 43937); Plainfield (AMNH 43929-31) ; Scotch Plains (ANSP 19318) .

Warren County: Great Meadows (AMNH 64086) ; Johnsonburg (AMNH 64084-5) .

SOUTHEASTERN PENNSYLVANIA 12 specimens.

Berks County: Birdsboro (JZSP 344) .

Delaware County: Drexel Hill (CA 12789-90) .

Montgomery County: Bryn Mawr (CA 12763) ; Penllyn (CA 12764-6) ; Summeytown (ZSP 47) .

Philadelphia County: Fairmount Park (ANSP 18348; JZSP 501; CA 12762); Torresdale (CA 12773) .

DEL-MAR-VA (Extreme northern portion Piedmont and Elk Neck)
—5 specimens.

DELAWARE: *New Castle County*: Wilmington (CA 12768).

MARYLAND: *Cecil County*: Elk Neck (CA 12769; CU 2784; USNM 107828) ; 1 mile east of Elkton (CA 12767) .

STATEN ISLAND AND LONG ISLAND—8 specimens.

Staten Island: Martling's Pond, Clove Lakes Park (AMNH 64669) ; New Brighton (AMNH 58077); St. George (AMNH 64668).

Long Island: (AM NH 3697); Huntington (AMNH 28726); New Lots (AMNH 3687); Yaphank (AMNH 38327, 38348).

SOUTHERN NEW JERSEY—46 specimens.

Atlantic County: 3 miles northwest of May's Landing (CU 1366) .

Burlington County: Marlton (ZSP 415); Mount Misery (ZSP 632); Taunton (ZSP 3470, 3501-2); Upton (ZSP 3370-1).

Camden County: Mount Ephraim (ZSP 382).

Cumberland County: Dorchester (ZSP 356); Vineland (A M NH 64658-65; ZSP 572-3, 578-82, 1522-5, 2781-2) .

Middlesex County: Spotswood (AMNH 43910).

Monmouth County: Allaire (UMMZ 74462); Matawan (AMNH 43895).

Ocean County: East Lakewood (CU 1276); 1 mile west of Forked River (AMNH 49215); Lakewood (CU 1277a-c; 1982, 2479a-b, 2480a-b, 3352a-b).

DEL-MAR-VA PENINSULA (Coastal Plain)-28 specimens.

DELAWARE: *Sussex County*: Ellendale (CA 12770); Oak Orchard (CA 12772).

MARYLAND: *Queen Anne's County*: Near Centerville (CU 2795, 2799).

Talbot County: 1 1/2 miles south of Wye Mills (CA 12771).

Worcester County: Berlin (CU 2794, USNM 75262); Near Bishopville (CU 2800); Corbin (CA 12774-88); Furnace Tract, near Snow Hill (USNM 107822); Pocomoke State Forest (CU 2797); Pocomoke State Park (CU 2796, 2798).

VIRGINIA: *Accomac County*: Chincoteague Island (USNM 107667).

SOUTHEASTERN VIRGINIA-11 specimens.

Nansemond County: Western Dismal Swamp (CM 23168).

New Kent County: Near Lanexa (CM 18580).

Princess Anne County: Southern Seashore State Park (CM 22891, 23010-2, 23166-7, 23169); 4 miles west of Virginia Beach (CM 23686-7).

DIFFERENCES BETWEEN THE TWO SUBSPECIES

The characteristics that Blanchard (*op. cit.*) considered as being diagnostic for *punctatus* and *edwardsii* may be summarized as follows:

- | <i>punctatus</i> | <i>edwardsii</i> |
|--|--|
| 1. A prominent row of dark spots extending down the center of the belly, posteriorly and usually irregularly | 1. Belly immaculate or marked (chiefly with a few dark spots or very small dots on the midventral line). |
| 2. Neck ring commonly interrupted or partly interrupted along the mid-dorsal line. | 2. Neck ring rarely interrupted. |
| 3. Chin and labials often spotted. | 3. Chin and labials normally immaculate. |
| 4. Sum of ventrals and subcaudals 190 or less. | 4. Sum of ventrals and subcaudals 190 or more. |

Each of the snakes listed above was carefully examined for these criteria, and a record was made of the characteristics which it exhibited. Since the degree of spotting upon the chin and belly is extremely variable and, in some series of specimens, may run the gamut from heavily marked to immaculate, certain more or less arbitrary rules were established for assigning snakes to the different categories. Likewise, the extent of interruption of the neck ring was judged according to definite standards. The classifications were as follows:

1. VENTRAL SPOTTING

- A. Spots completely absent or with three or fewer very small dark dots.
- B. Spots present although faint, few in number, or highly irregular.

Table I. Variation in Ring-necked Snakes from Southern New Jersey, the Del-Mar-Va Peninsula, and Adjacent Areas.

Number of Specimens	Area	Sum of Ventrals Plus Subcaudals		Ventral Spotting			Neck Ring		Chin and Labial Spotting Present
		Extremes	Mean	Absent	Slight	Prominent	Complete	Intermediate	
				A	B	C	D	E	F
28	Pocono Mountains	199-217 (22)*	209.4	17 (61%)	9 (32%)	2 (7%)	27 (96%)	0	1 (4%)
25	Northern New Jersey	195-217 (21)	206.1	13 (52%)	6 (24%)	6 (24%)	21 (84%)	2 (8%)	2 (8%)
12	Southeastern Penna.	196-208 (11)	204.7	5 (42%)	5 (42%)	2 (16%)	12 (100%)	0	0
5	Del-Mar-Va (Piedmont & Elk Neck)	198-211 (5)	203.4	3 (60%)	1 (20%)	1 (20%)	5 (100%)	0	0
8	Staten and Long Islands	203-215 (5)	212.2	4 (50%)	2 (25%)	2 (25%)	6 (75%)	1 (12.5%)	1 (12.5%)
46	Southern New Jersey (including Lakewood and Vineland series)	181-204 (40)	189.2	6 (13%)	6 (13%)	34 (74%)	22 (48%)	9 (19%)	15 (33%)
11	Lakewood, N. J.	181-194 (10)	188.7	2 (18%)	1 (9%)	8 (73%)	2 (18%)	4 (36%)	5 (46%)
21	Vineland, N. J.	183-196 (18)	188.7	2 (9.5%)	2 (9.5%)	17 (81%)	12 (57%)	3 (14%)	6 (29%)
28	Del-Mar-Va (Coastal Plain) (including Corbin series)	182-198 (23)	190.3	1 (4%)	5 (18%)	22 (78%)	19 (68%)	2 (7%)	7 (25%)
15	Corbin, Md.	182-198 (11)	190.5	0	4 (27%)	11 (73%)	11 (73%)	1 (7%)	3 (20%)
11	Southeastern Virginia	175-190 (10)	183.9	0	0	11 (100%)	2 (18%)	1 (9%)	8 (73%)

*Figures in parentheses in this column refer to the number of specimens with perfect tails, hence those upon which complete counts could be made.

C. Spots prominent on the midventral line. All snakes placed in this category were at least as conspicuously patterned as the specimen of *punctatus* from southeastern Virginia which showed the least amount of ventral spotting.

2. NECK RING

D. Light-colored ring complete across neck.

E. Neck ring partially interrupted along the middorsal line.

F. Neck ring completely interrupted.

3. CHIN SPOTTING

G. Two or more dark spots or streaks on the lower labials, chin shields, or scales of the throat.

The number of specimens falling into each of the above classifications (from each of the several areas) is indicated in Table I. A study of this table reveals a number of significant facts. It is clearly evident, for example, that there is a gradual decrease in the number of scales on the underside of the body (ventrals plus subcaudals) from northern areas to southern ones and from the mountains and the piedmont to the coastal plain. Thus, the population samples from the Pocono Mountains, northern New Jersey, southeastern Pennsylvania, and the extreme northern portion of Del-Mar-Va—all upland regions show a higher average number of scales than do the population samples from the coastal plain areas. There is a definite downward trend that is readily apparent upon an inspection of the column headed "Mean."* It is of special interest to note that the populations from southern New Jersey and the Del-Mar-Va Peninsula literally straddle the figure (190) which Blanchard used to separate *edwardsii* from *punctatus*. Populations that are intermediate between these two subspecies would be expected to have more or less intermediate scale counts. The means for specimens from Lakewood and Vineland, New Jersey, and from Corbin, Maryland, are all in close agreement with those for the general areas of which they are a part. Statistics for these three localities are presented separately in the table in order to show the amount of variation that is evident in restricted local populations.

Mathematical data based on scale counts obtained from four of the series of specimens are presented in Table II.

In the matter of ventral spotting (referring again to Table I) there is also a trend from north to south and from upland to lowland. Few snakes from the mountains or piedmont have the maculations well enough

*Data obtained from the small series of specimens from Staten and Long Islands do not fit the above generalizations. More material from these two localities is needed, and it is probable that, when it becomes available, it will exhibit a lower average number of scales than do the few snakes already studied.

Table II. Interquartile Ranges, etc., Based upon the Sum of the Ventrals and Subcaudals in Four Population Samples of Ring-necked Snakes.

Number of Specimens	Area	Males plus Females				Mean for Males	Mean for Females
		Extremes	Mean	Interquartile Range	Coefficient of Variation		
22 (7♂, 15♀)	Pocono Mountains (typical <i>edwardsii</i>)	199 to 217	209.4±1.05	206.1 to 212.7	2.35%	206.7	210.7
40 (25♂, 15♀)	Southern New Jersey (<i>punctatus</i> x <i>edwardsii</i>)	181 to 204	189.2±.71	186.2 to 192.2	2.37%	189.1	189.4
23 (12♂, 11♀)	Del-Mar-Va Peninsula (<i>punctatus</i> x <i>edwardsii</i>)	182 to 198	190.3±.95	187.2 to 193.4	2.38%	189.3	191.4
10 (6♂, 4♀)	Southeastern Virginia (typical <i>punctatus</i>)	175 to 190	183.9±1.31	181.1 to 186.7	2.6%	182.8	185.5

developed to be called prominent, whereas all of those from southeastern Virginia do. In this characteristic, the populations from southern New Jersey and the Del-Mar-Va Peninsula include some individuals with unspotted abdomens, many with a prominent row of spots, and others that have these markings developed to a lesser extent.

A study of the condition of the neck ring (whether it is complete, interrupted, or partly so) reveals the same geographic trend, the frequency of interruption being greatest in the Virginia series. The figures for the amount of dark spotting on the chin and labials are less significant, largely because it is difficult to reduce such a characteristic to a mathematical calculation. In general, it is true, however, that these markings are more numerous and considerably more intense in southern specimens, and that the South Jersey and Del-Mar-Va snakes, as a whole, include the entire range of possibilities from no spots to many of them.

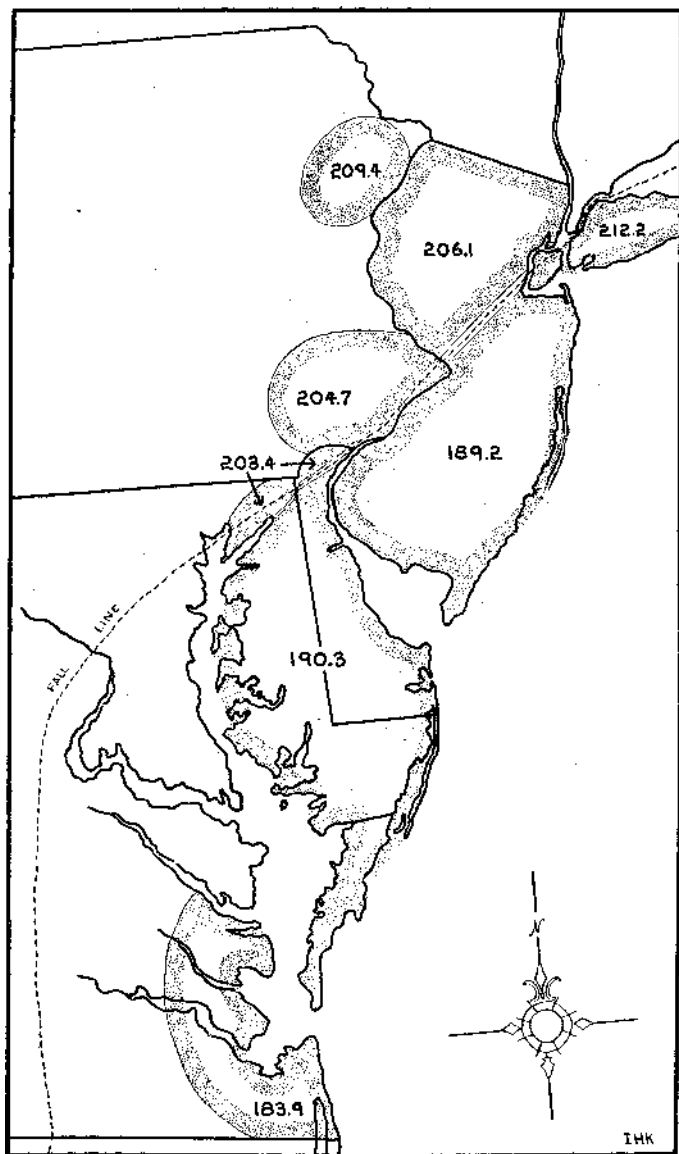
The time-honored, but now largely discontinued, practice of attempting to assign a definite scientific name to each individual specimen would be futile in the case of the ring-necked snakes of the northern part of the Atlantic Coastal Plain. The intergrading populations that live in the region include individuals that are indistinguishable from *edwardsii*, others that might be called *punctatus*, and still others that combine the characters of the two and cannot be assigned definitely to either. Thus, among twenty-one snakes from Vineland, New Jersey, there are four that might be identified as *edwardsii*, six as *punctatus*, and eleven as intermediates. A similar condition prevails in each of the series from Lakewood and Corbin. The populations indigenous to both southern New Jersey and the Del-Mar-Va Peninsula exhibit evidences of mixed genes and no definite label can be attached to any of the individual snakes that form a part of them. If a name were to be assigned to the group as a whole it should be *Diadophis punctatus punctatus* x *edwardsii*.

SUMMARY

1. The evidence at hand shows that the ring-necked snakes inhabiting southern New Jersey and the Del-Mar-Va Peninsula constitute an intergrading population between the two subspecies, *edwardsii* and *punctatus*.

2. Populations referable to *edwardsii* occur in the Pocono Mountains of northeastern Pennsylvania, in northern New Jersey, in southeastern Pennsylvania, and in the northernmost portion of the Del-Mar-Va area. A population identifiable as *punctatus* inhabits southeastern Virginia.

3. There is a gradual trend in scale counts and markings from *edwardsii* to *punctatus* from north to south and from upland to lowland.



Map showing the areas from which population samples of *Diadophis* were studied. Each number indicates the arithmetical mean of the sum of the ventral and subcaudal counts made upon ring-necked snakes from the respective area.

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